University of Nebraska
Medical Center

Oscillatory Dynamics of Motor Control

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Support & Disclosures

NSF National Science Foundation
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NIH *Eunice Kennedy Shriver* National Institute of Child Health and Human Development
Health research throughout the lifespan

NIH **National Institute on Drug Abuse**
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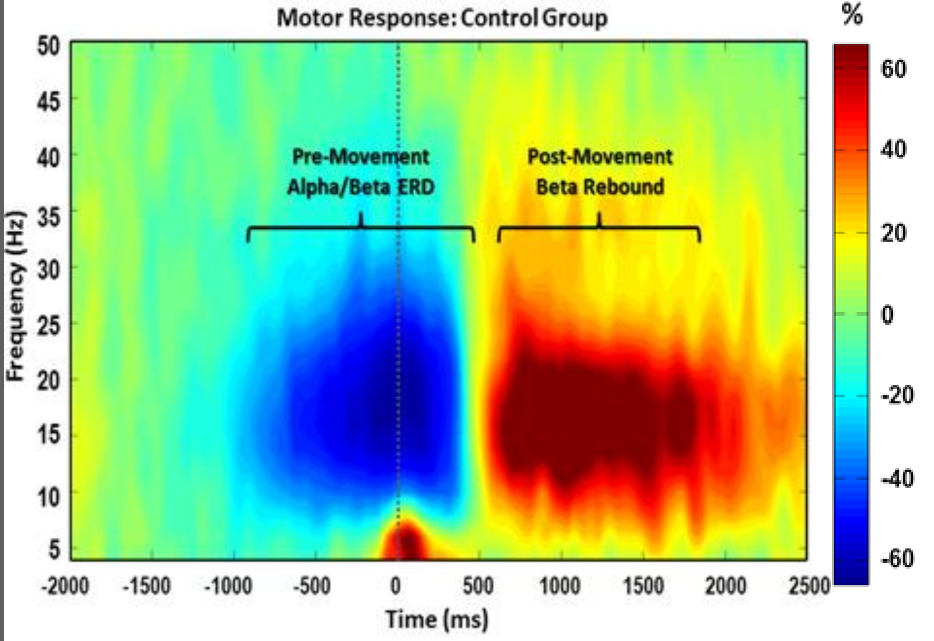
Outline

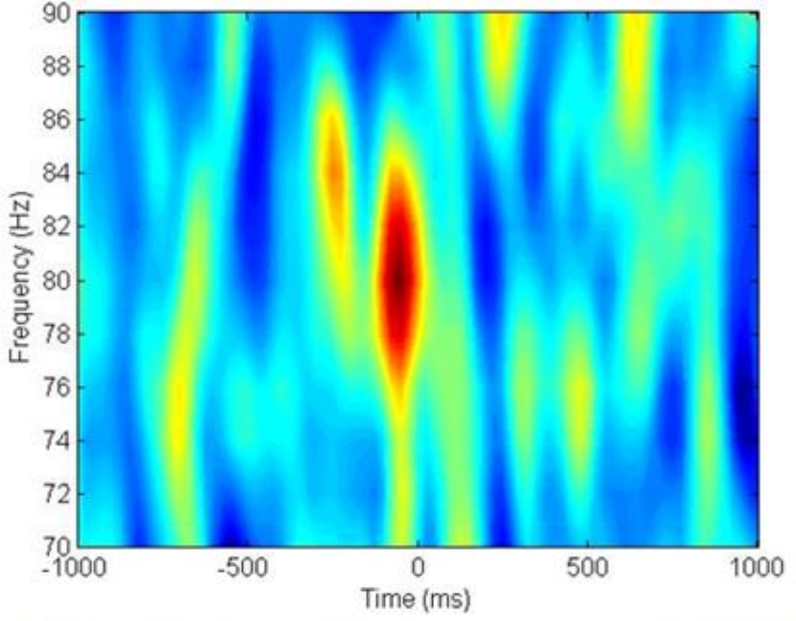
- Motor-related Oscillatory Responses
  - Complimentary to evoked potentials
  - More tolerant of within-subject latency variability
  - Generally less affected by artifacts

- The impact of specific movement parameters
  - Physical parameters of the movement
  - Cognitive parameters associated with the movement

- Spontaneous activity and oscillatory strength

Motor-related Oscillations





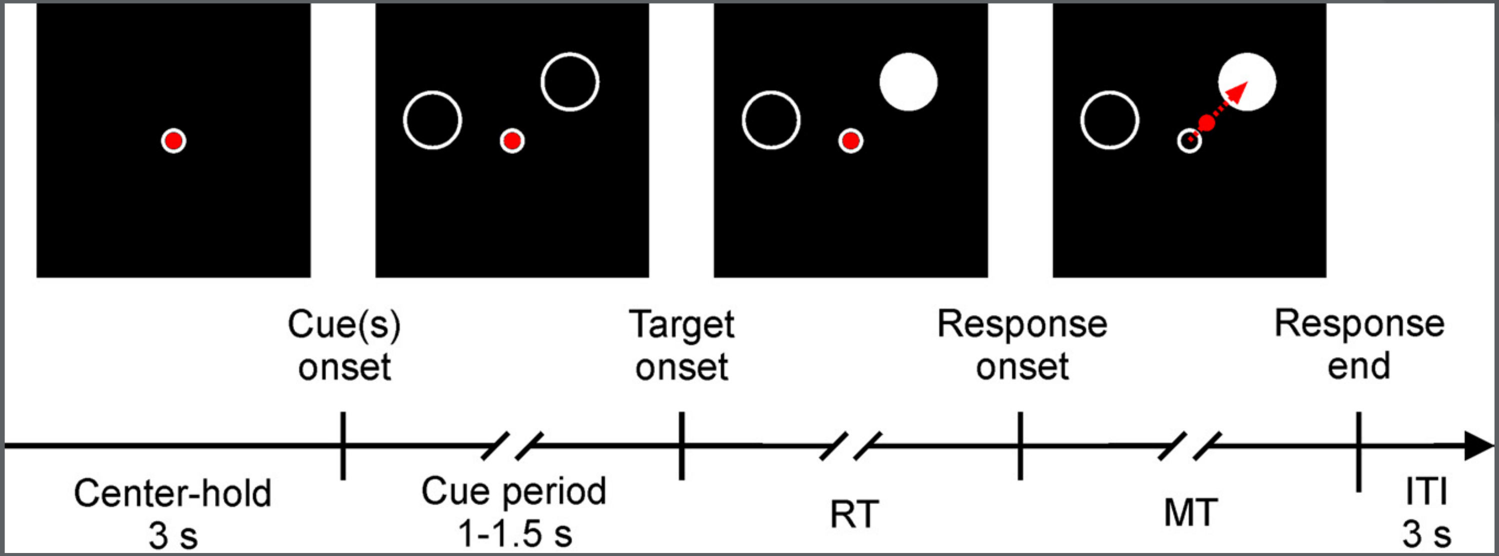
- Peri-movement beta ERD
- Post-Movement Beta Rebound (PMBR)
- Alpha ERD and theta range ERS
- Movement-related gamma synchronization

Peri-Movement Beta ERD

Generally speaking, the peri-movement beta ERD response:

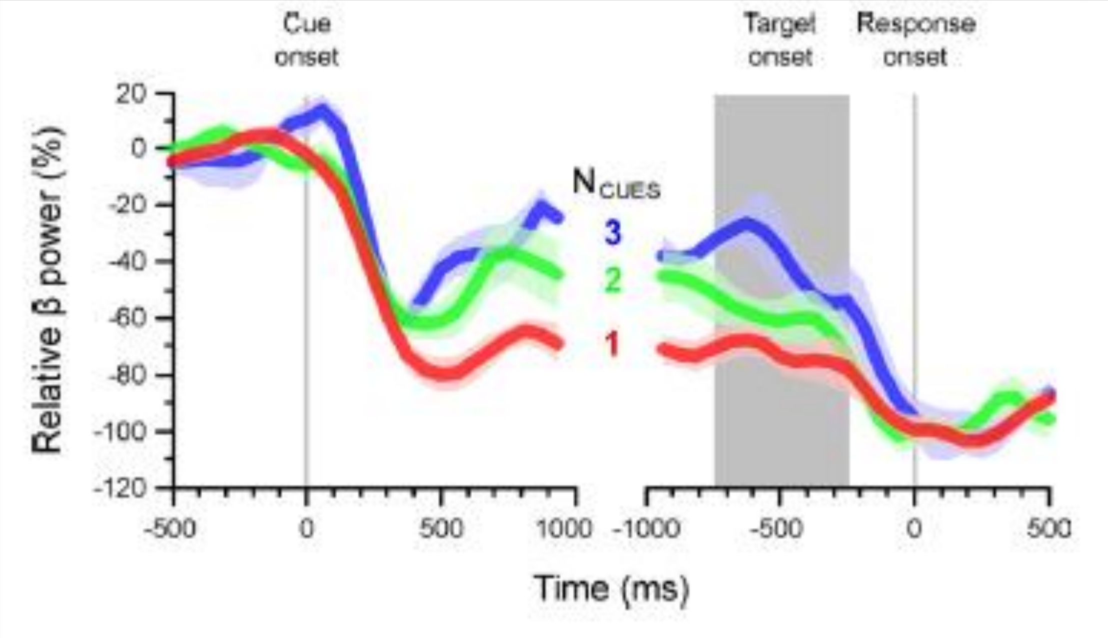
- Begins several hundred milliseconds before movement onset extends until termination
- Much stronger in the hemisphere contralateral to movement, but commonly bilateral
- Often the response is strongest in the primary motor cortex and extends into surrounding sensorimotor regions.
- Is affected by the physical aspects of the movement (e.g., duration), but also by many cognitive components.

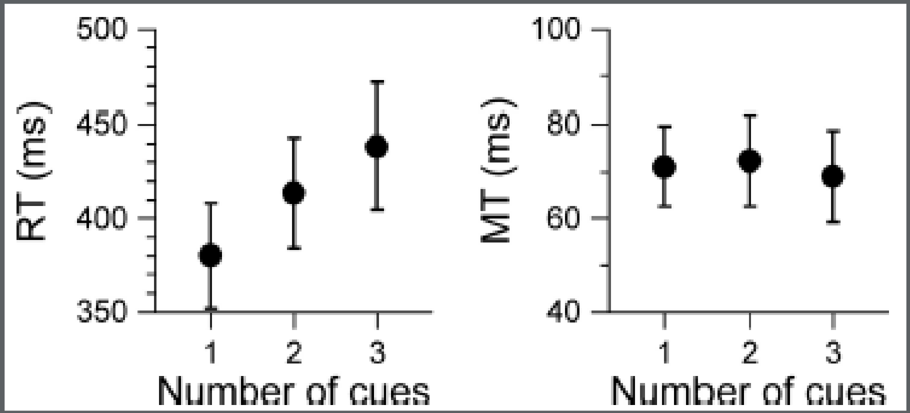
Movement Uncertainty



Tzagarakis et al., *J of Neuroscience*, 2010

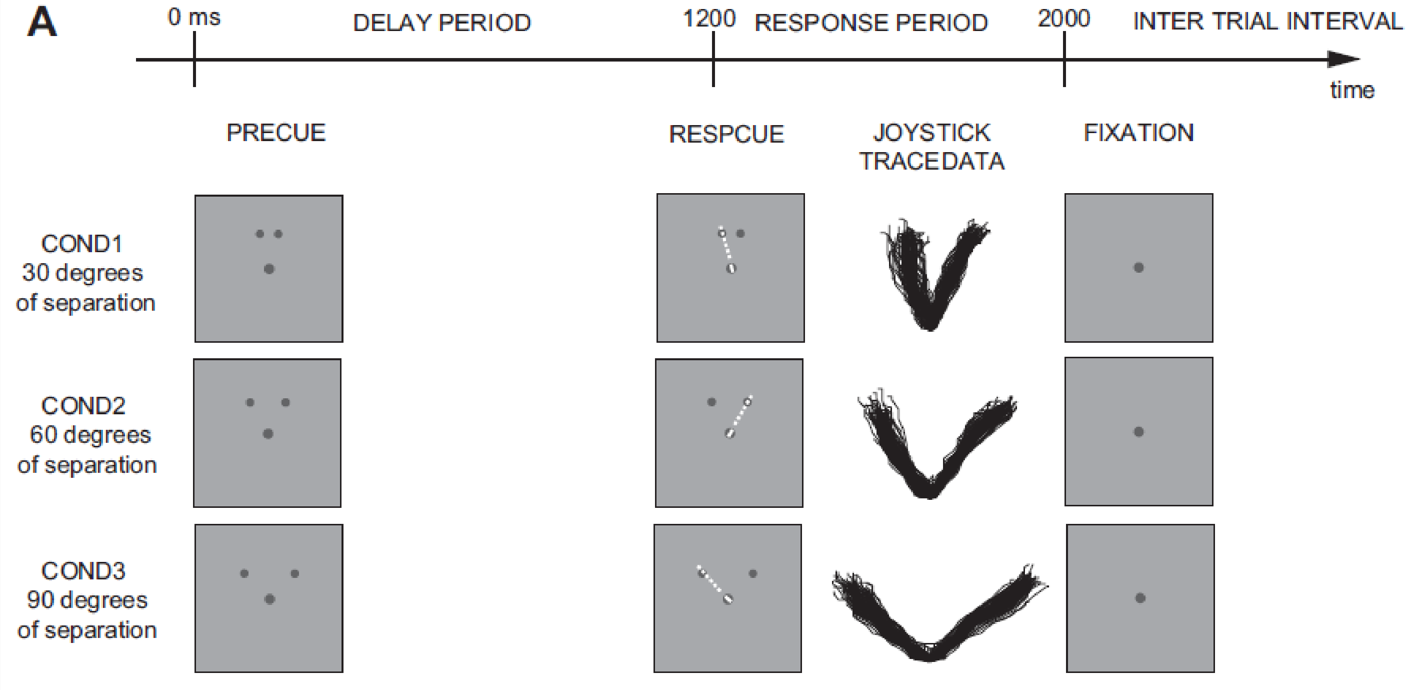
Movement Uncertainty

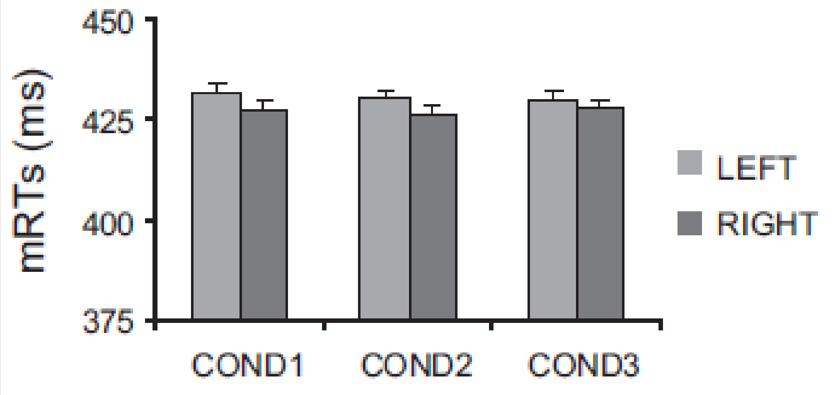




Tzagarakis et al., *J of Neuroscience*, 2010

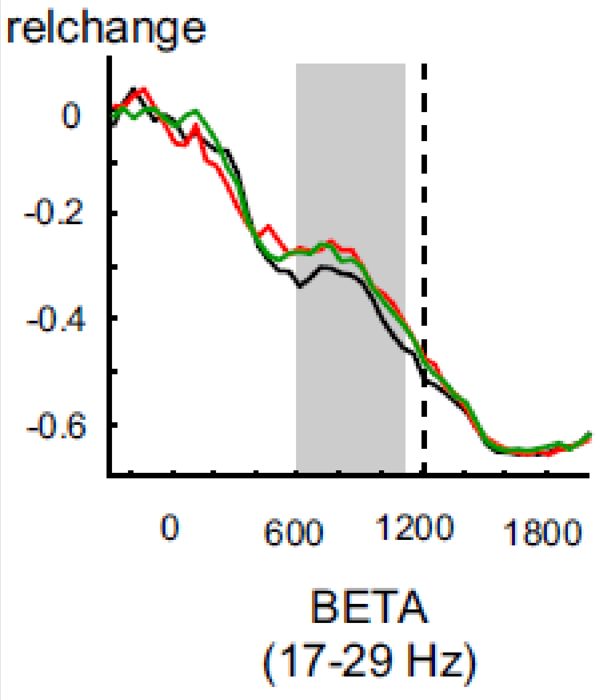
Similarity among possible movements





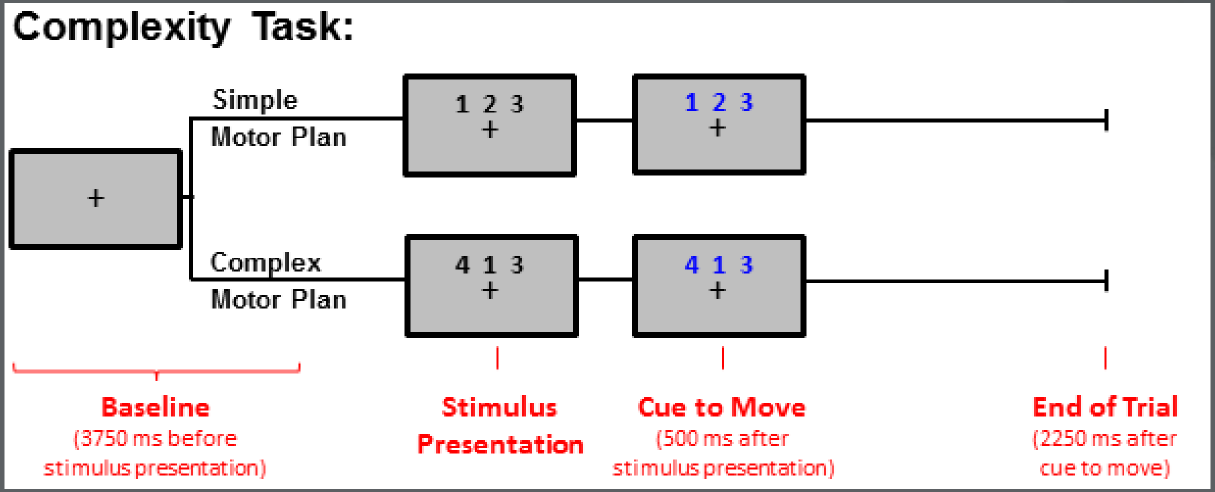
Grent-’t-Jong et al.,
J of Neurophysiology, 2014

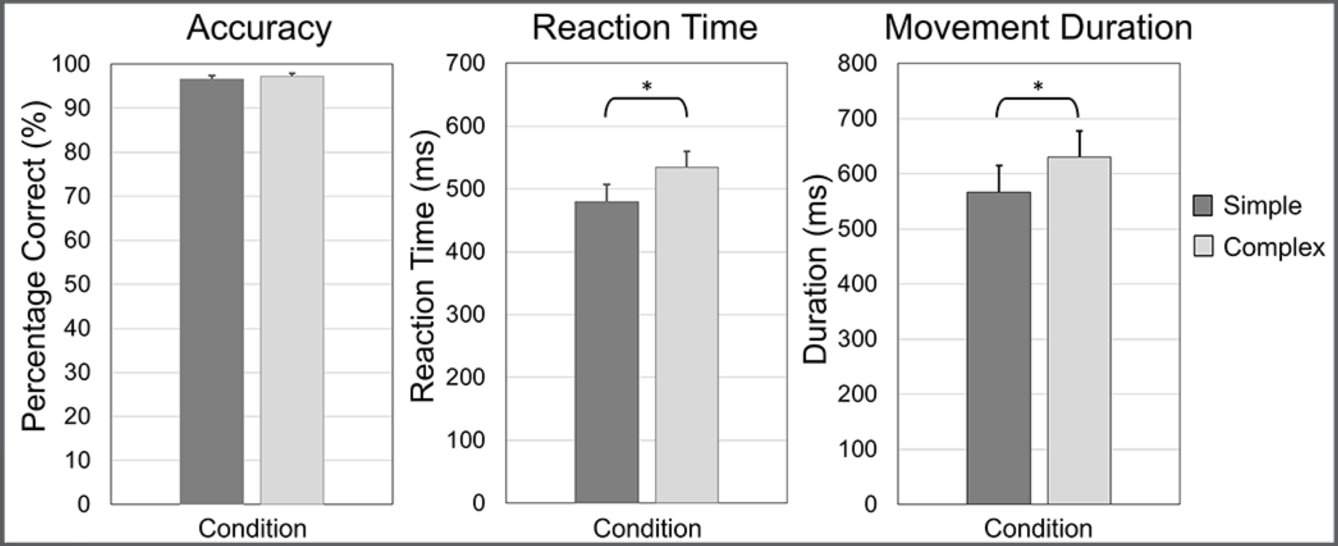
Similarity among possible movements



Grent-'t-Jong et al.,
J of Neurophysiology, 2014

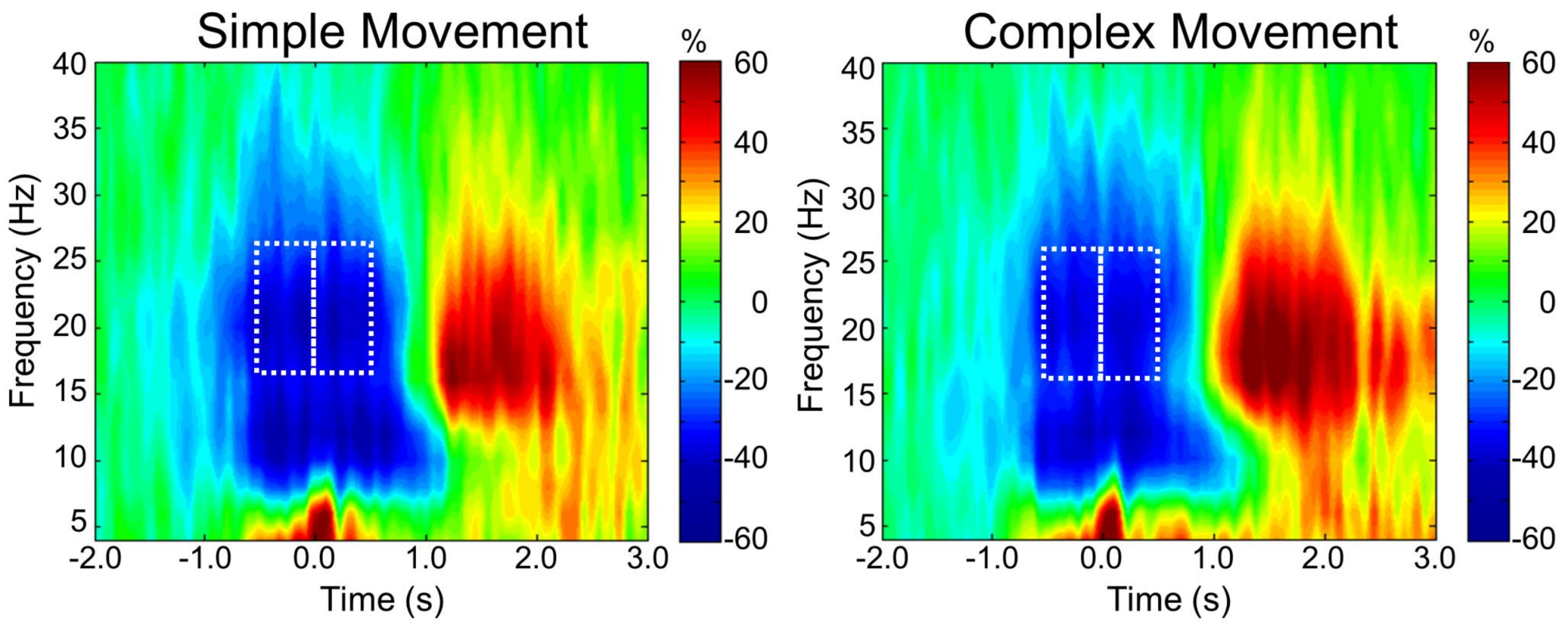
Movement Complexity





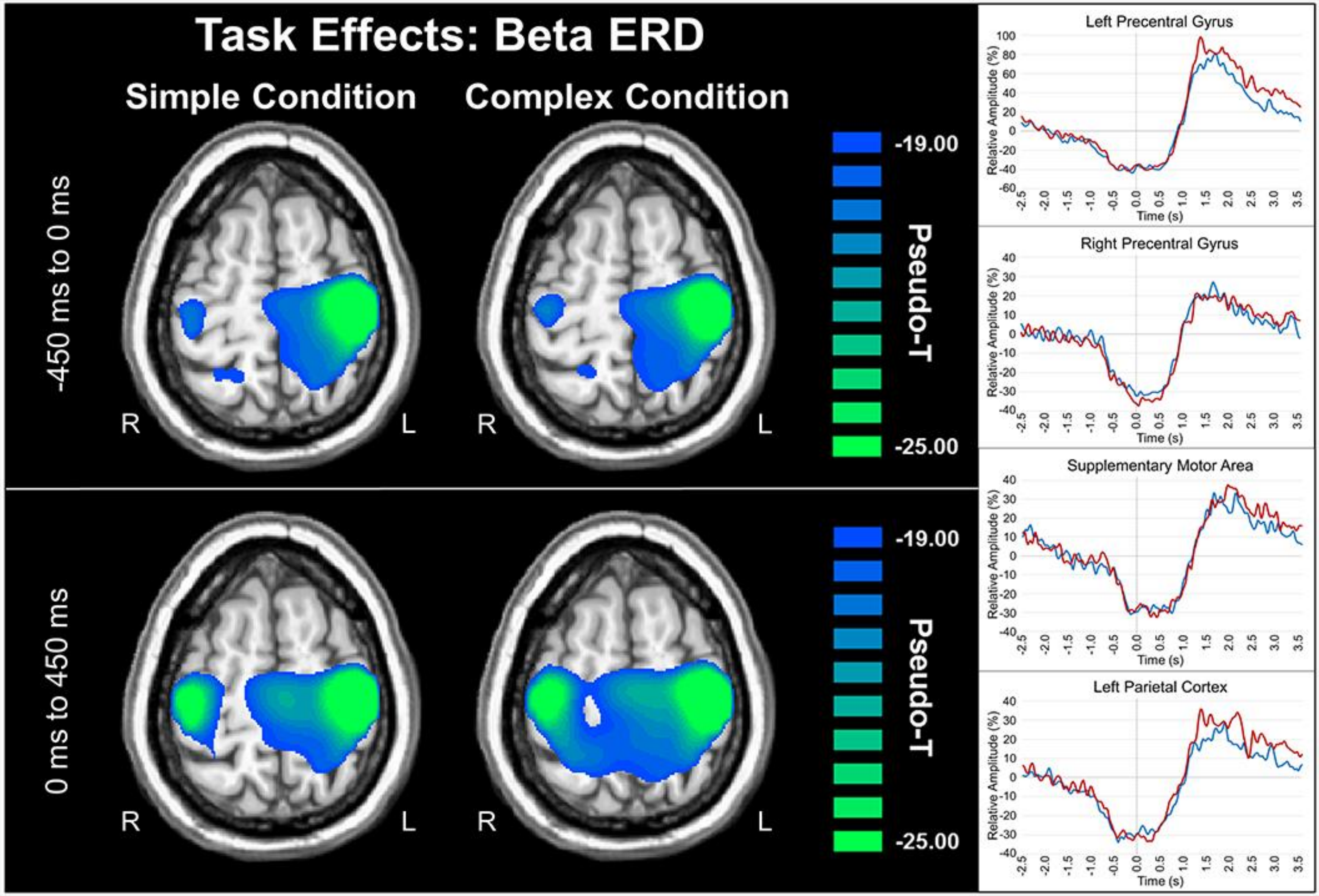
Heinrichs-Graham & Wilson, *Human Brain Mapp*, 2015

Movement Complexity



Heinrichs-Graham & Wilson, *Human Brain Mapp,* 2015

Movement Complexity



Heinrichs-Graham & Wilson, *Human Brain Mapp,* 2015

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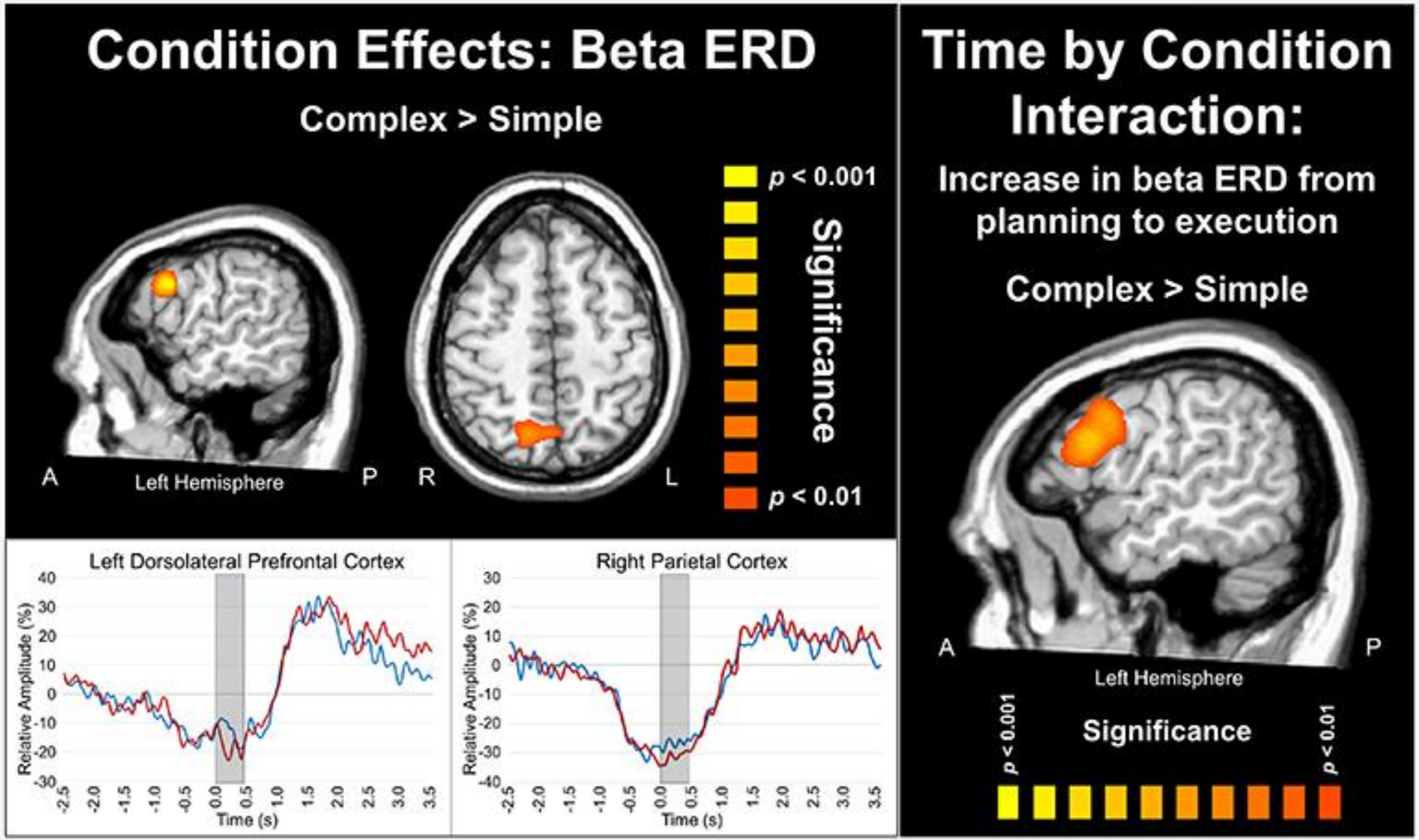
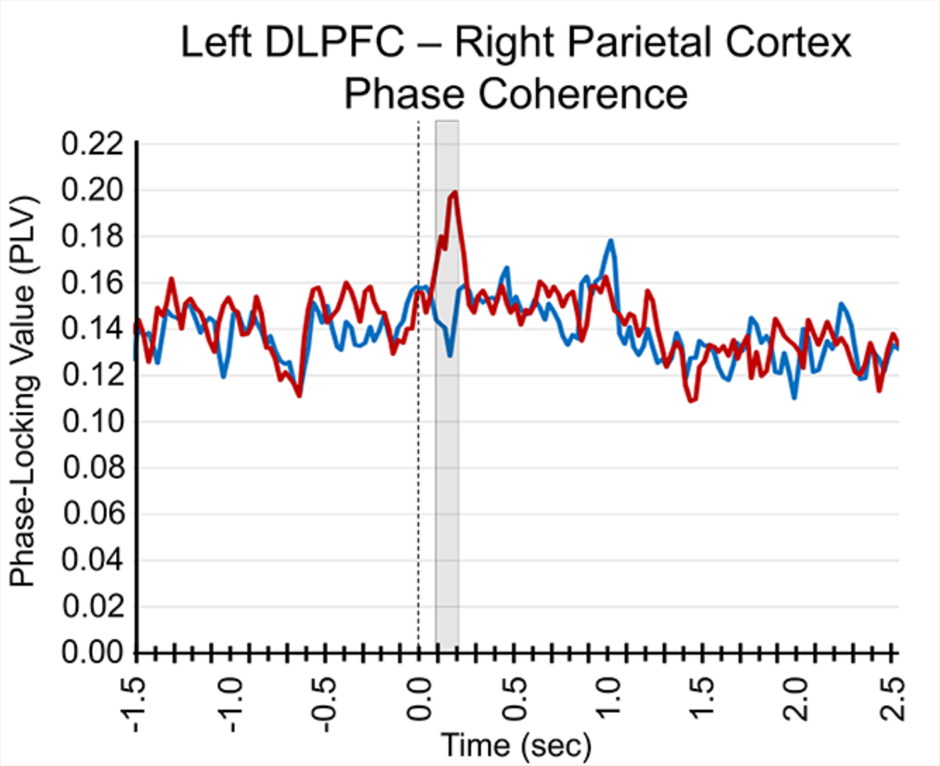


Heinrichs-Graham & Wilson, *Human Brain Mapp*, 2015

Movement Complexity



Heinrichs-Graham & Wilson, *Human Brain Mapp*, 2015

Other parameters: beta ERD

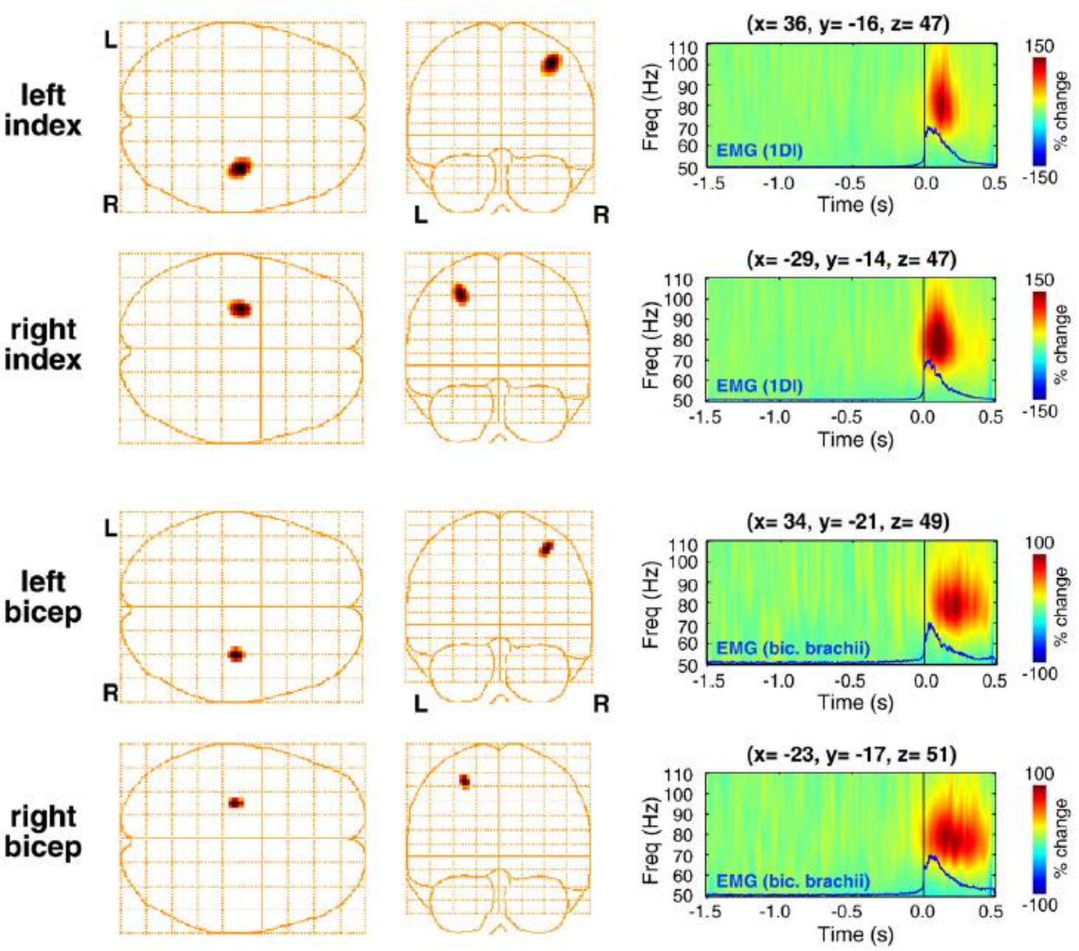
- Motor Planning Time – Heinrichs-Graham et al., *J of Cogn Neurosci*, 2016
- Response Competition – Grent-’t-Jong et al., *Neuroimage*, 2013
- Development & Aging – Heinrichs-Graham & Wilson, *Neuroimage*, 2016; Heinrichs-Graham et al., *Developmental Cogn Neurosci,* 2018
- Time of day – Wilson et al., *Neuroimage*, 2014
- Other parameters

Gamma ERS Response

Generally speaking, the movement-related gamma response:

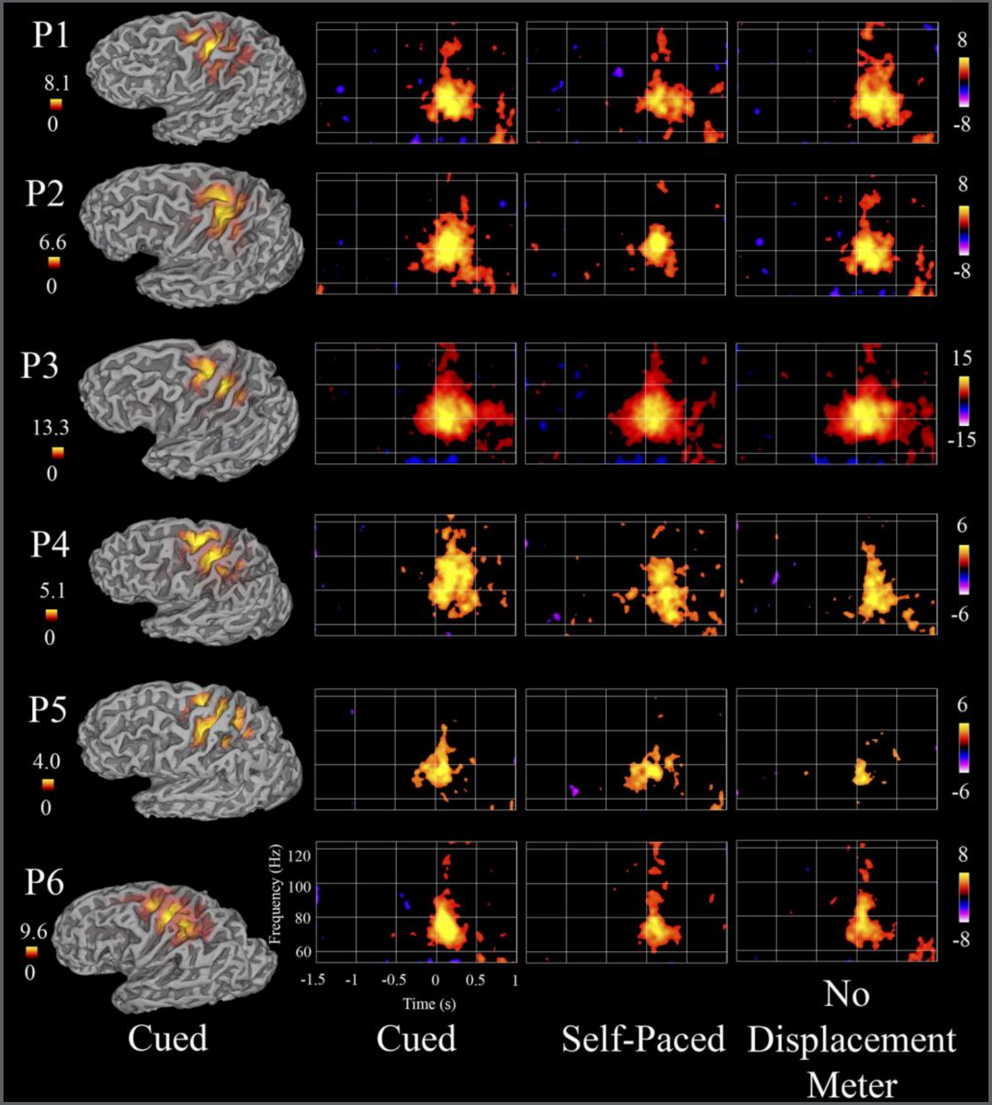
- More transient than beta (~200 ms duration)
- Starts at or near the movement onset
- More lateralized than beta
- Generated by neural populations near the motor-hand knob feature of the primary motor cortex
- Appears to be more affected by the physical aspects of the movement than by the cognitive components.

Parameters Modulating Gamma ERS



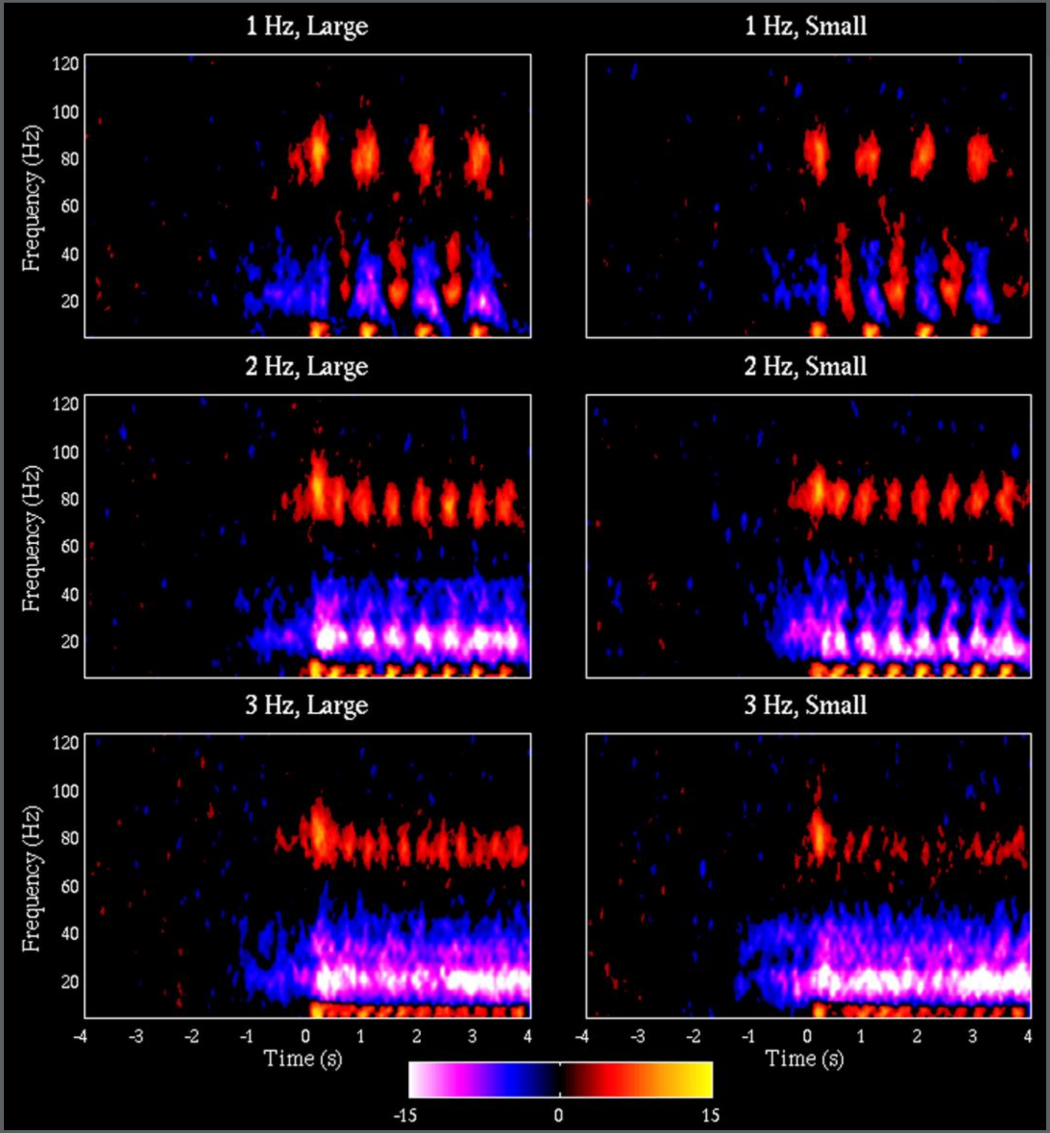
Cheyne et al., *Neuroimage*, 2008

Parameters Modulating Gamma ERS



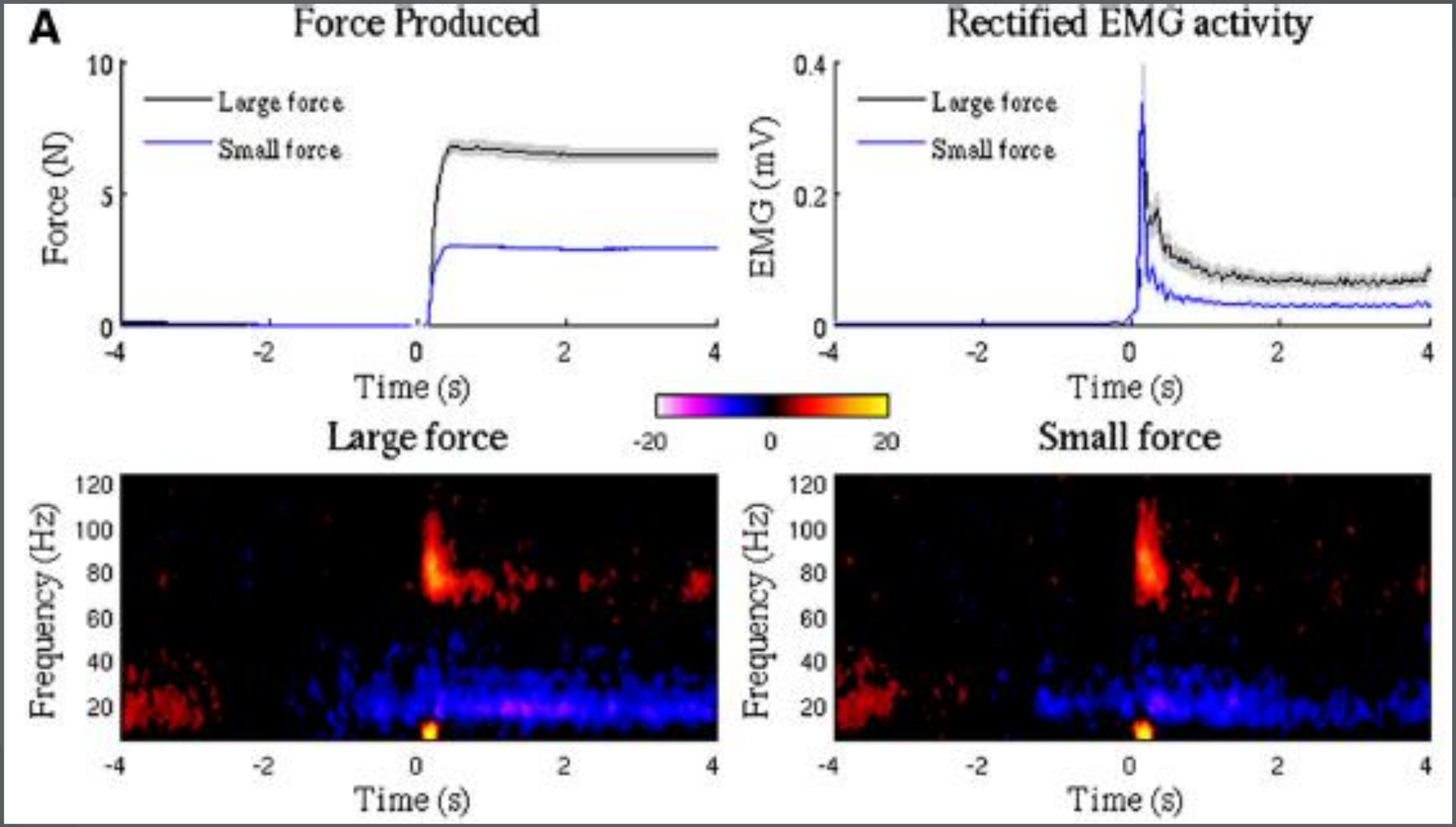
Muthukumaraswamy, *J of Neurophysiology*, 2010

Parameters Modulating Gamma ERS



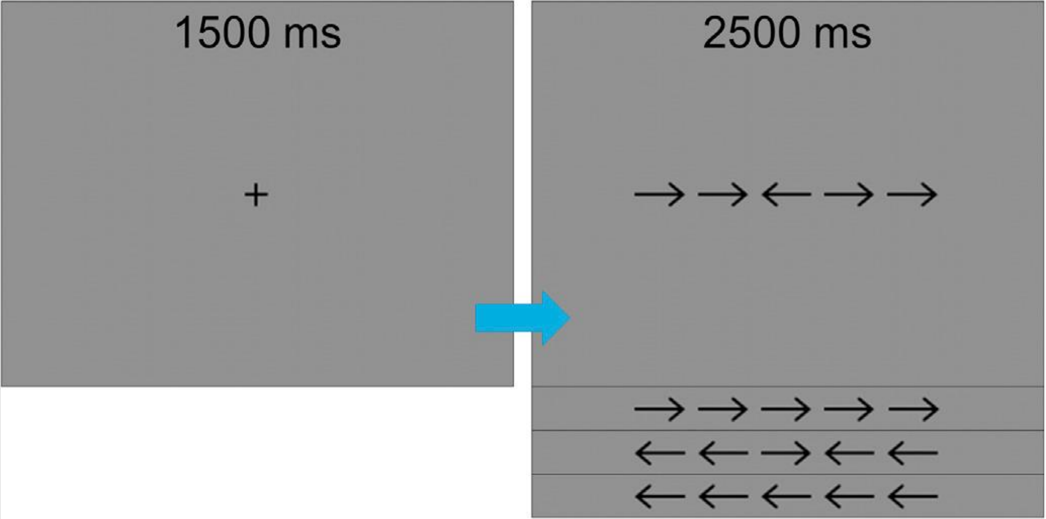
Muthukumaraswamy, *J of Neurophysiology*, 2010

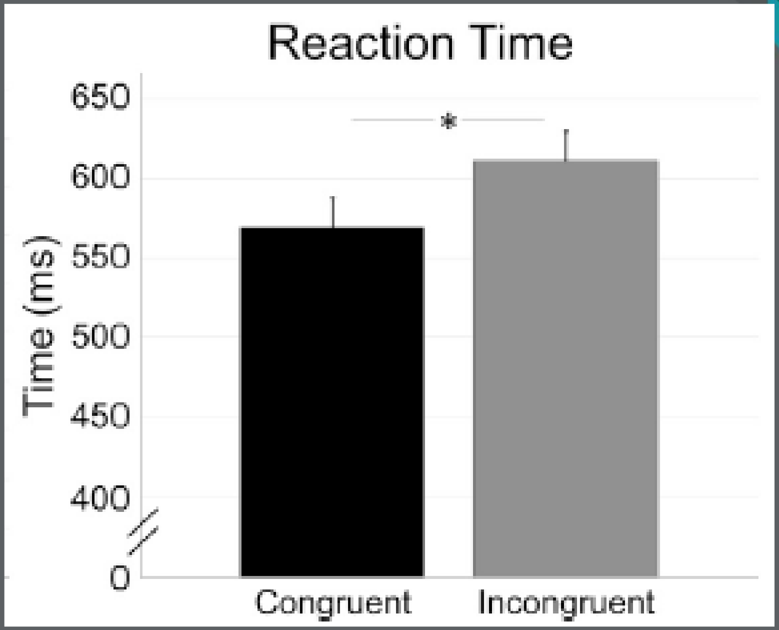
Parameters Modulating Gamma ERS



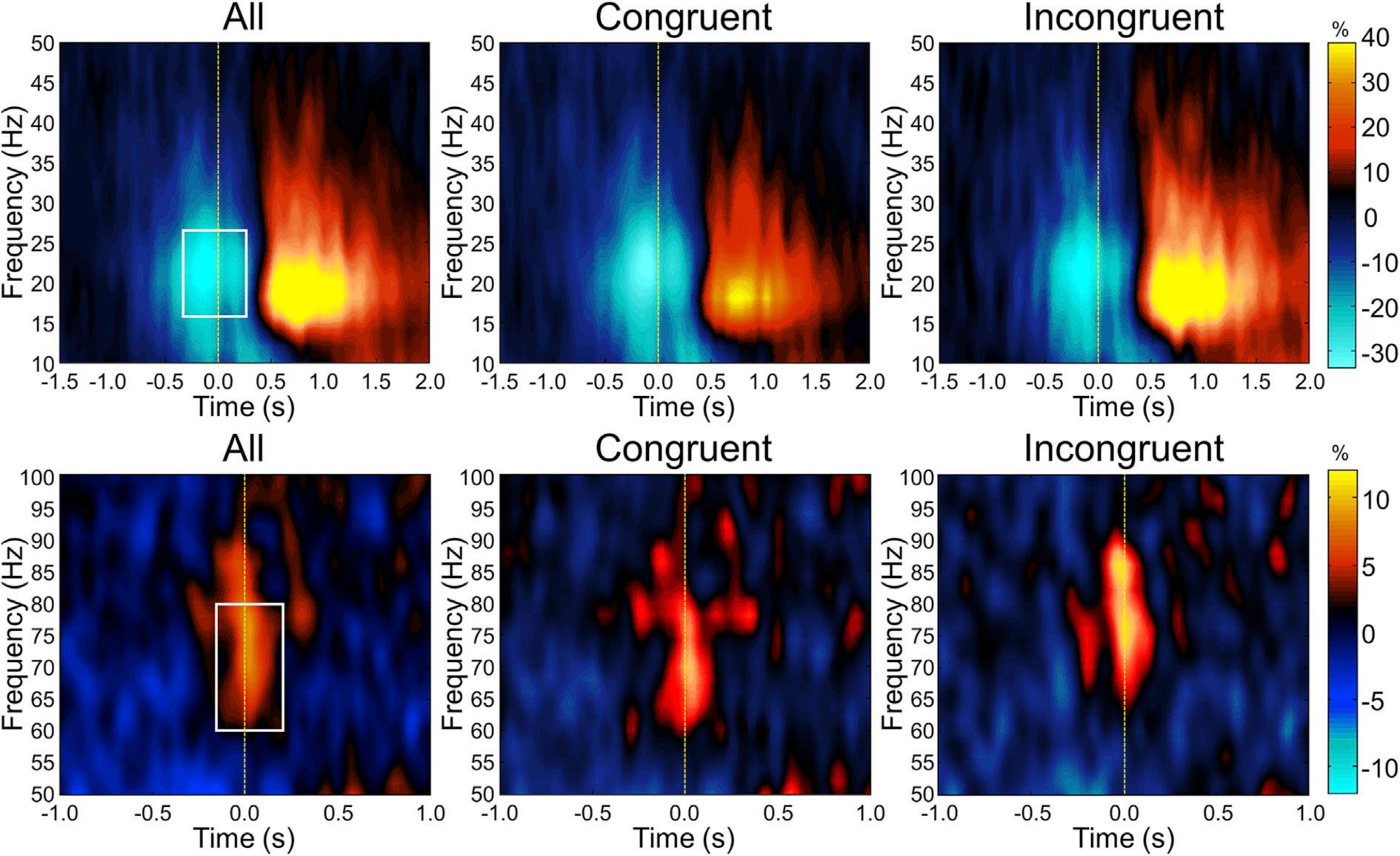
Muthukumaraswamy, *J of Neurophysiology*, 2010

Cognitive Parameters & the Gamma ERS

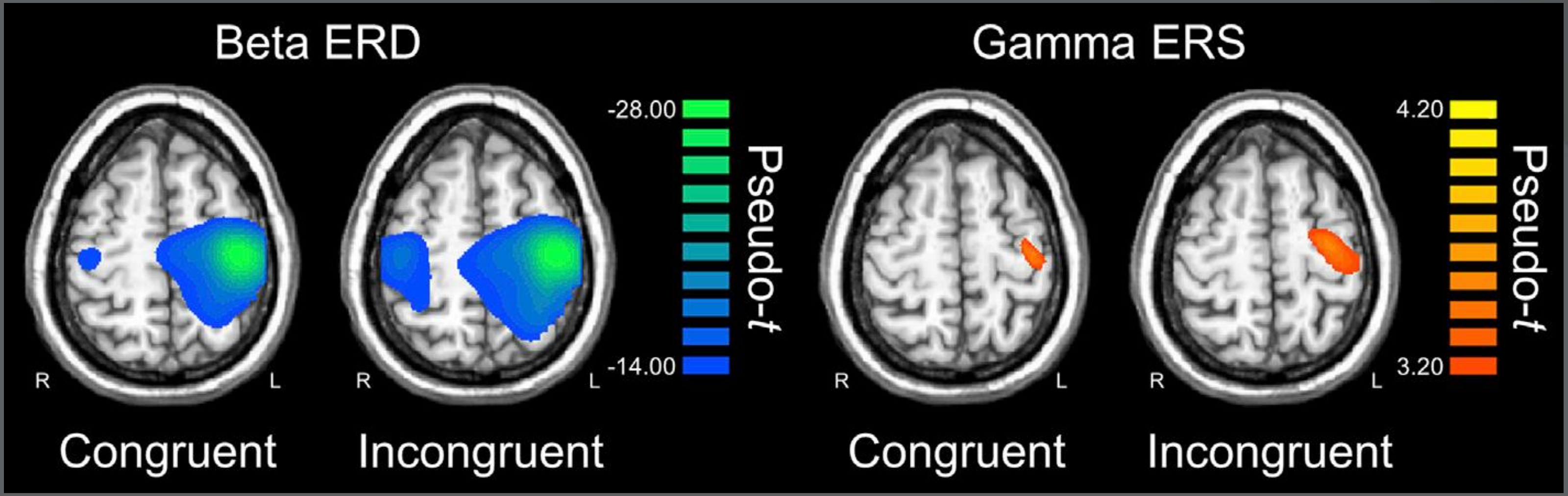




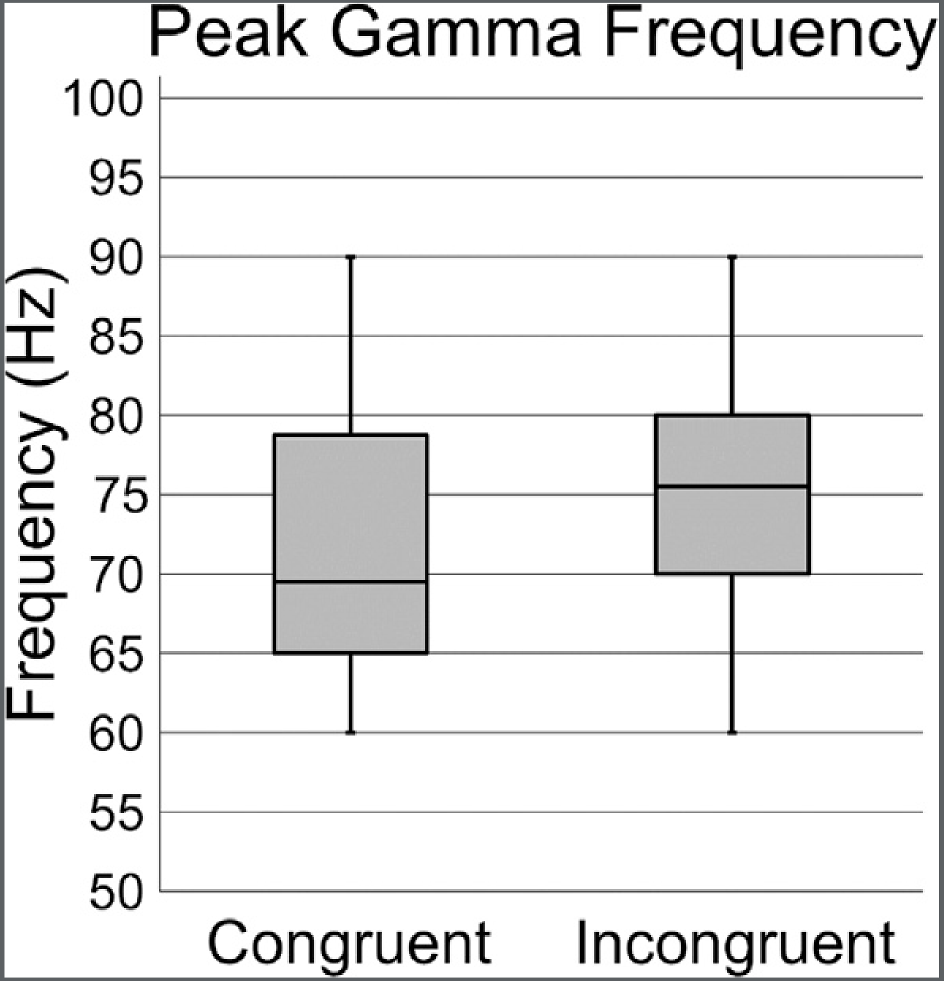
Flanker Effect & Gamma ERS



Flanker Effect & Gamma ERS



Flanker Effect & Gamma ERS



More about cognitive features modulating motor oscillations:

See poster: Spooner et al., W-006, *Top-down influence on sensory and motor gamma responses during reorienting of attention.*

Spontaneous Activity & Beta ERD

- Well known that spontaneous occipital alpha activity varies with the circadian cycle.

- Motor performance affected by biological clock

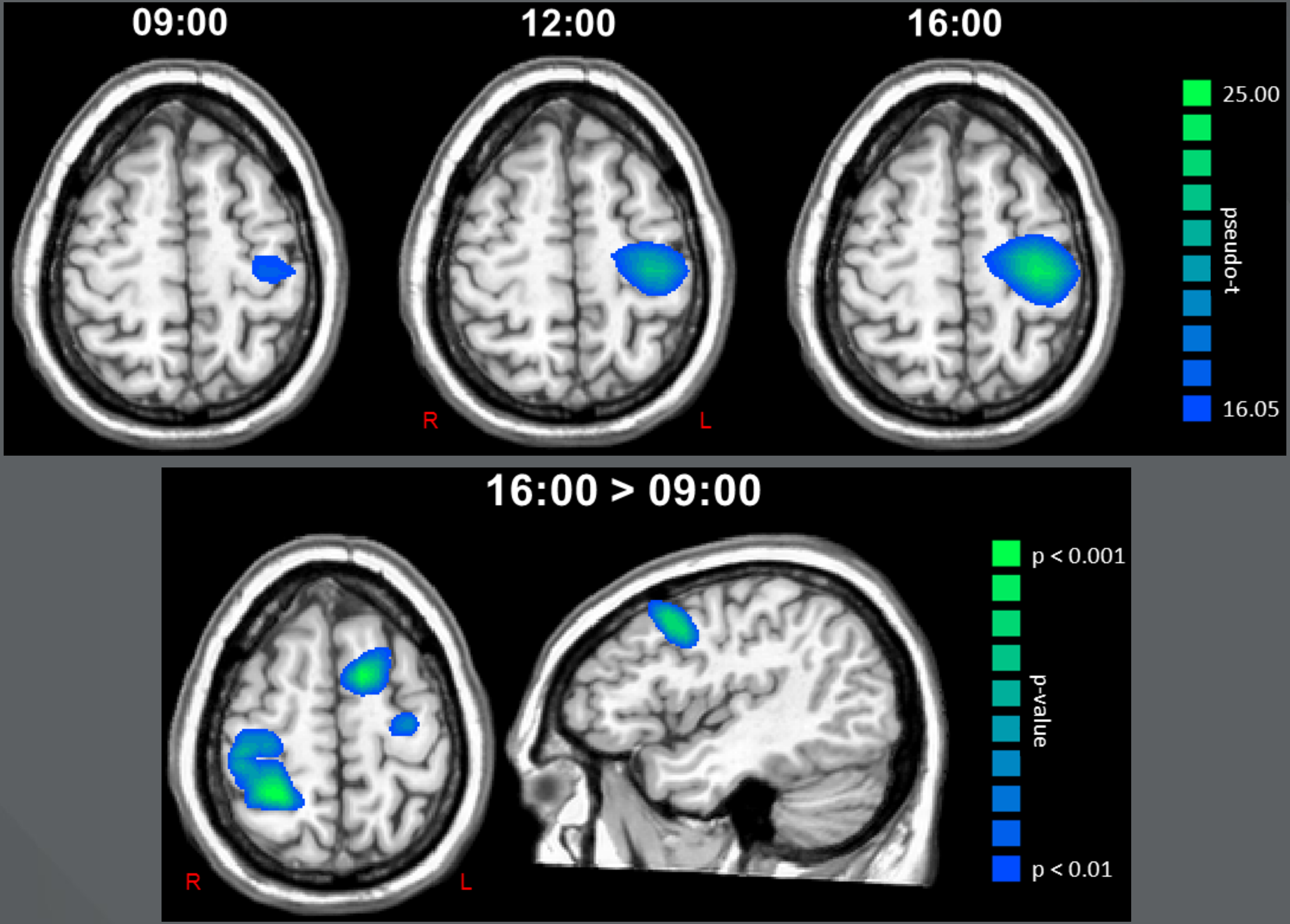
Does the beta ERD vary with the circadian cycle and is this related to spontaneous beta levels?

Circadian Modulation of Beta ERD

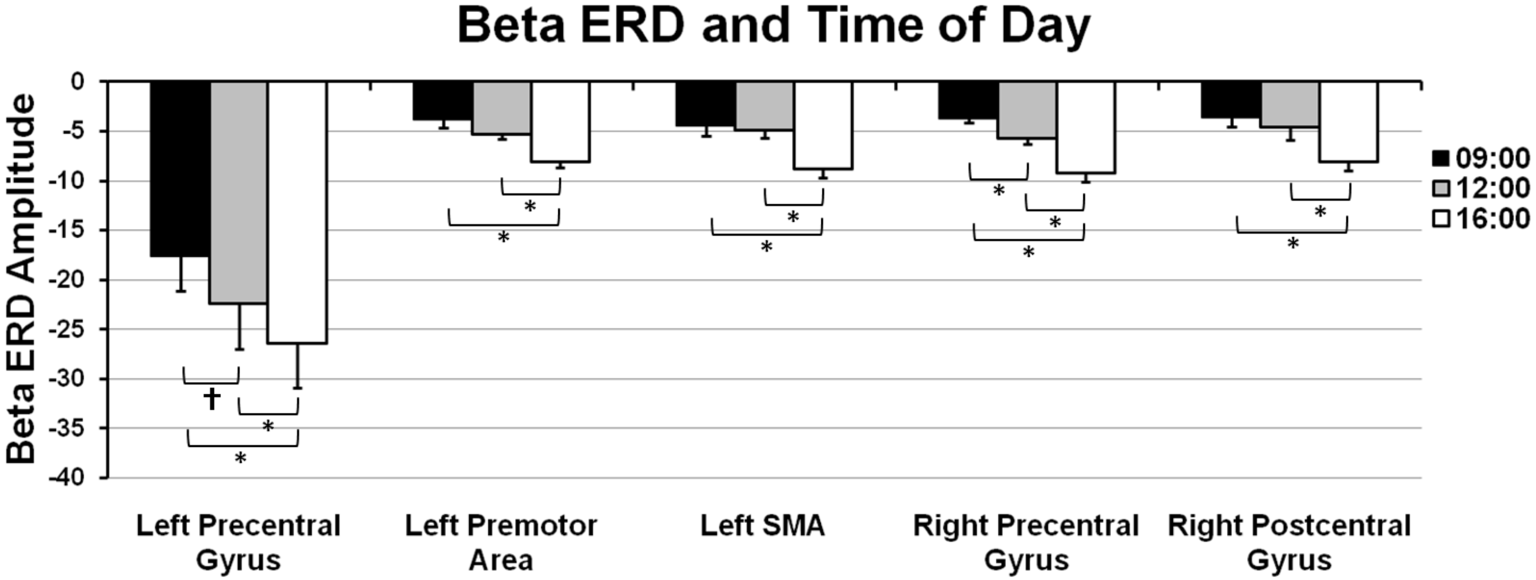
- Four participants recorded at 09:00, 12:00, and 16:00 on three consecutive days.
- Thus, 9 recordings per person and 36 total MEG recordings
- Focused on beta ERD responses

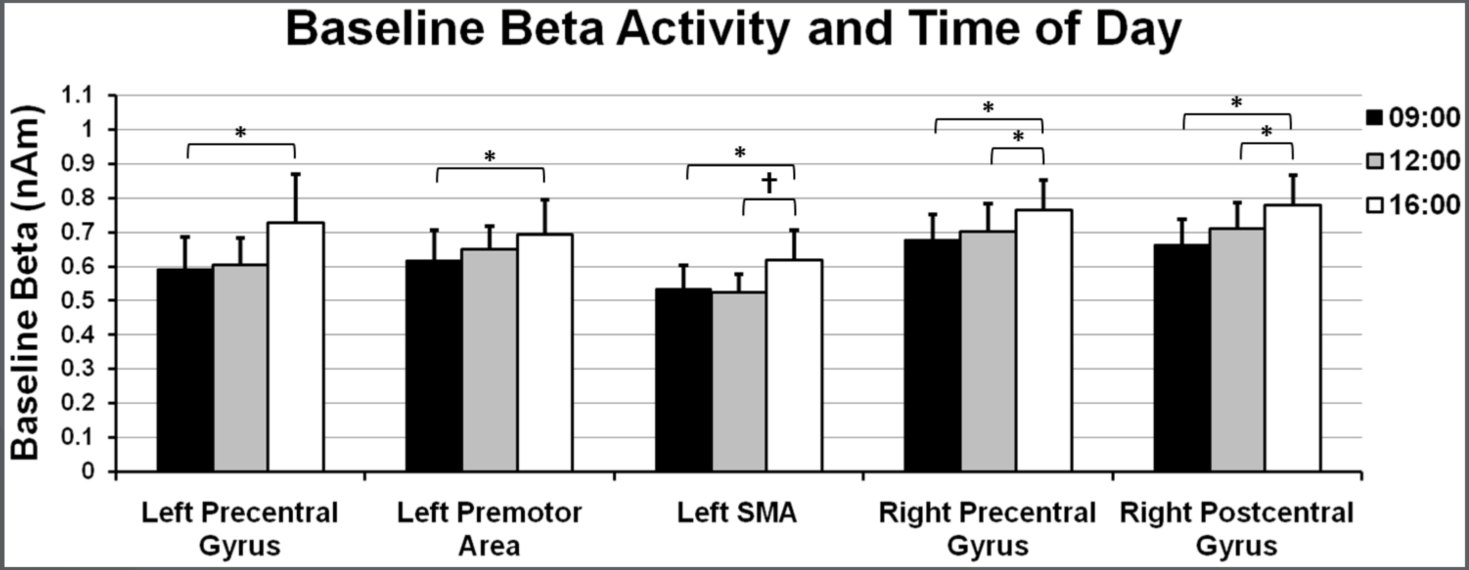
Wilson et al., *Neuroimage*, 2014a

Circadian Modulation of Beta ERD



Wilson et al., *Neuroimage*, 2014a


Beta ERD and Time of Day


Baseline Beta Activity and Time of Day

Wilson et al., *Neuroimage*, 2014a

Conclusions

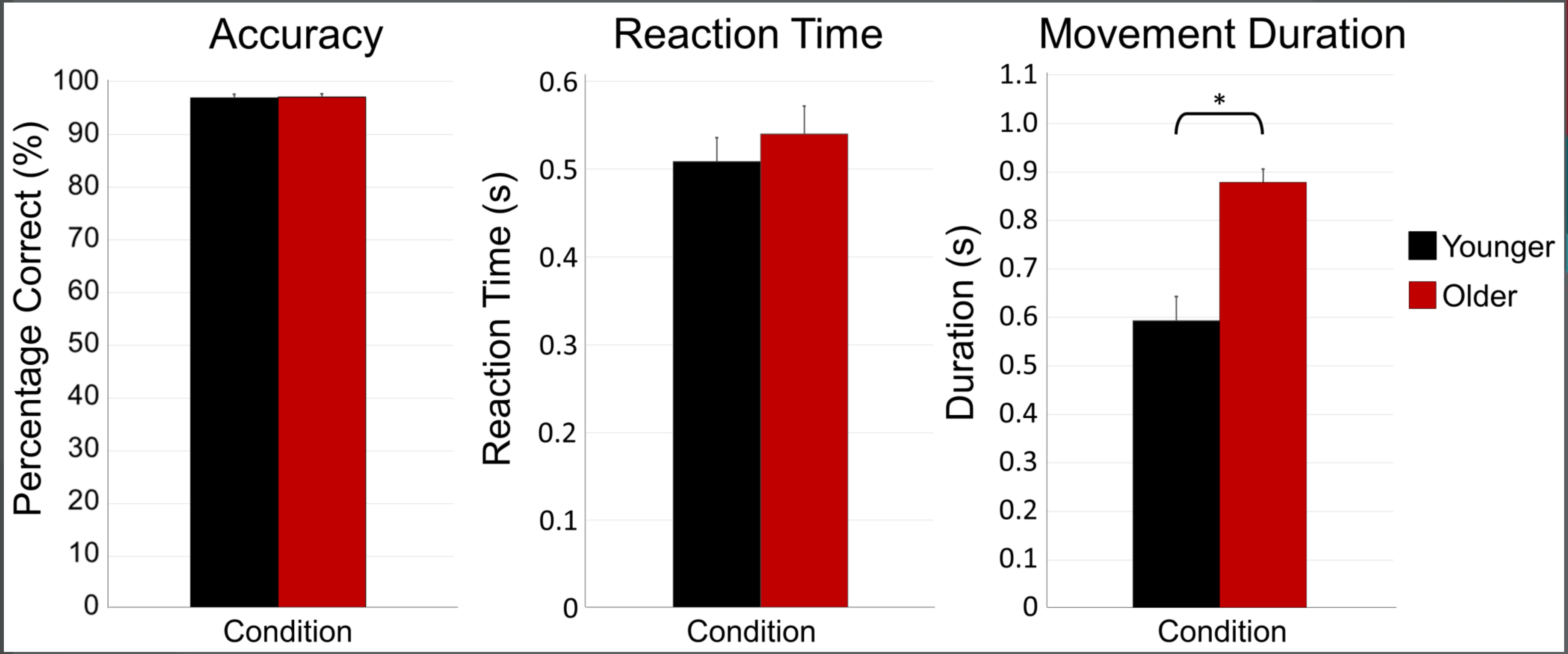
- Beta ERD and resting-state beta are stronger during the afternoon.

- Resting beta increases are restricted to motor cortices (not shown)

- Data supports existence of a “beta threshold” for movement execution

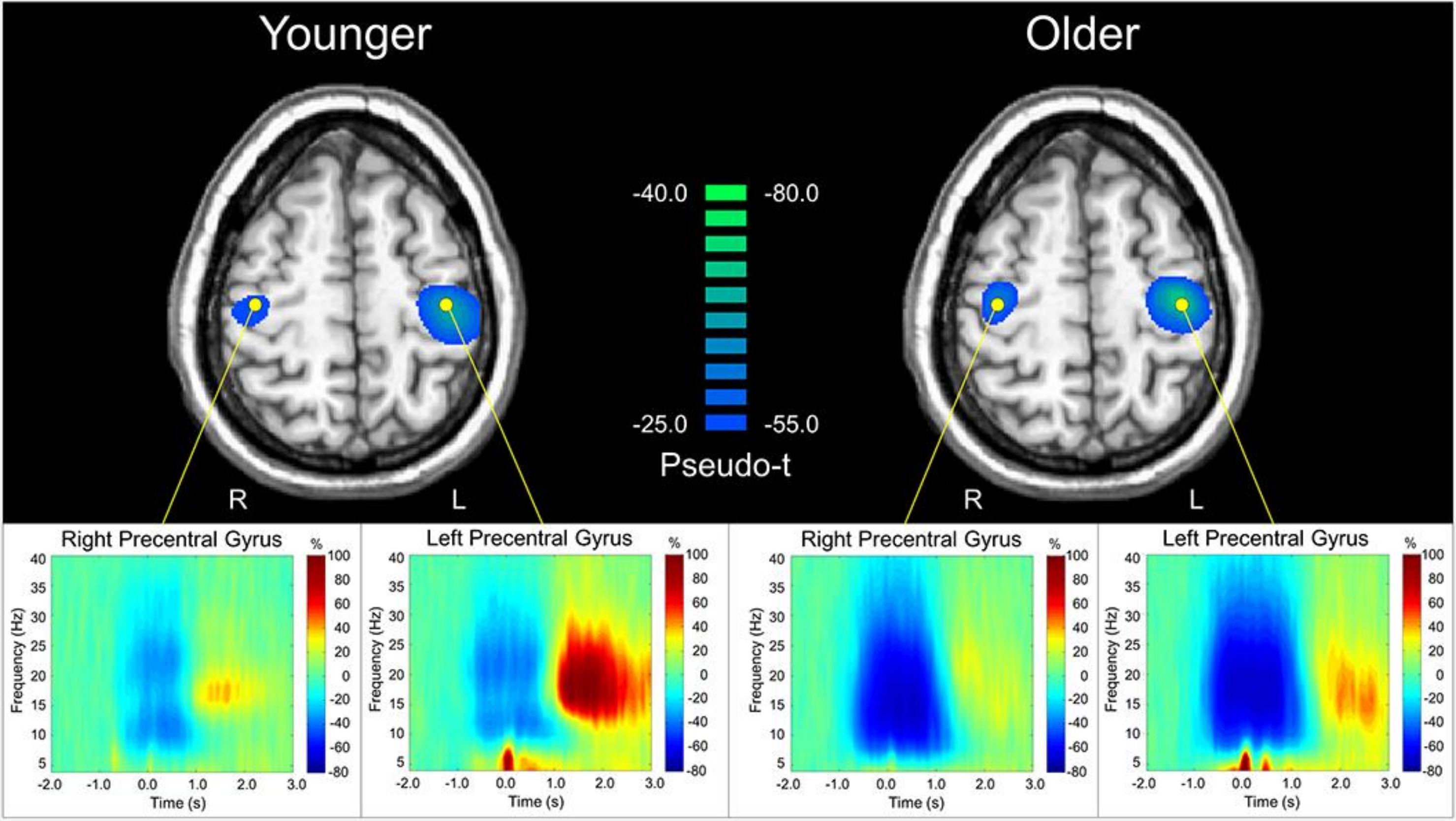
Wilson et al., *Neuroimage*, 2014a

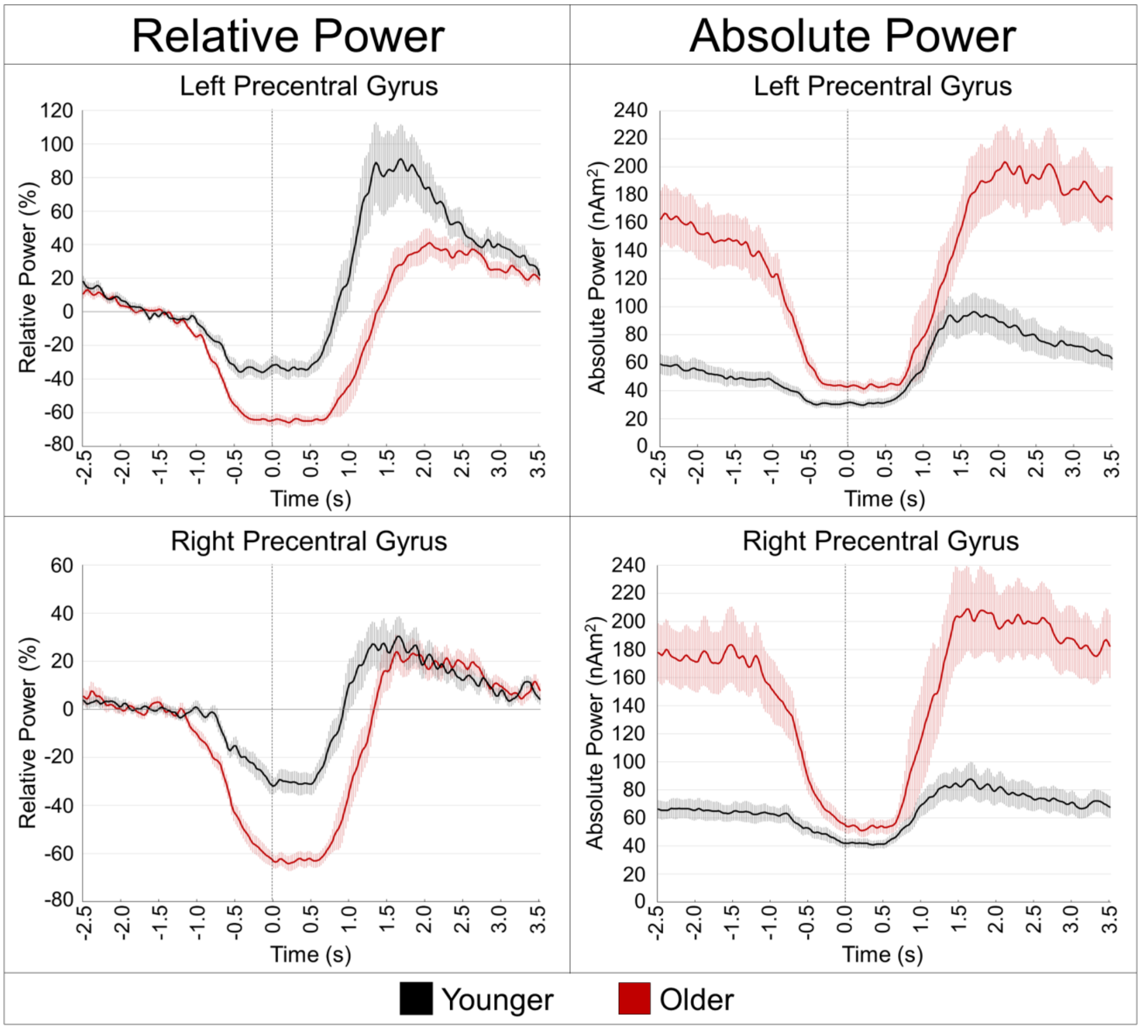
Aging & the Beta ERD



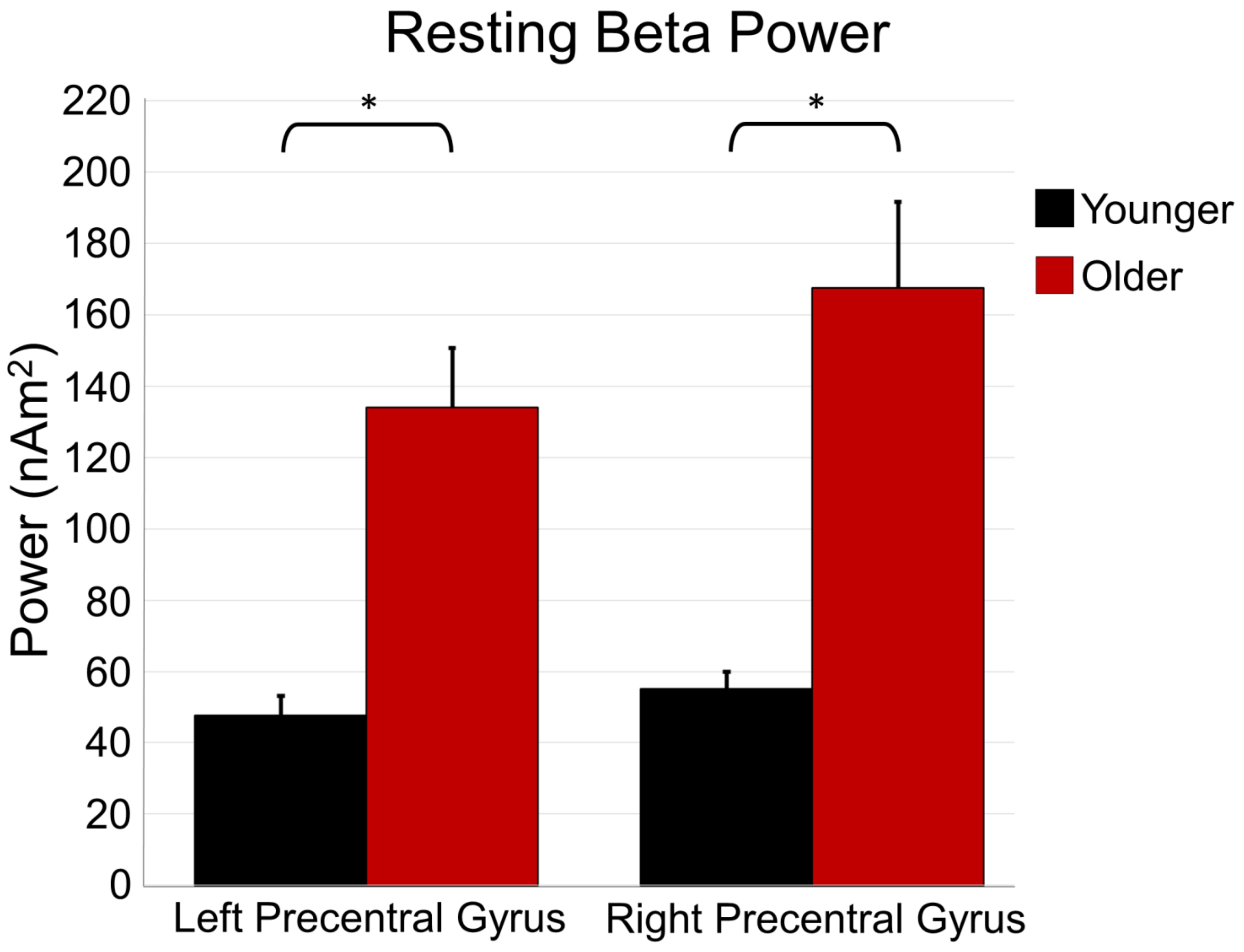
Heinrichs-Graham & Wilson, *Neuroimage*, 2016

Peri-Movement Beta Responses



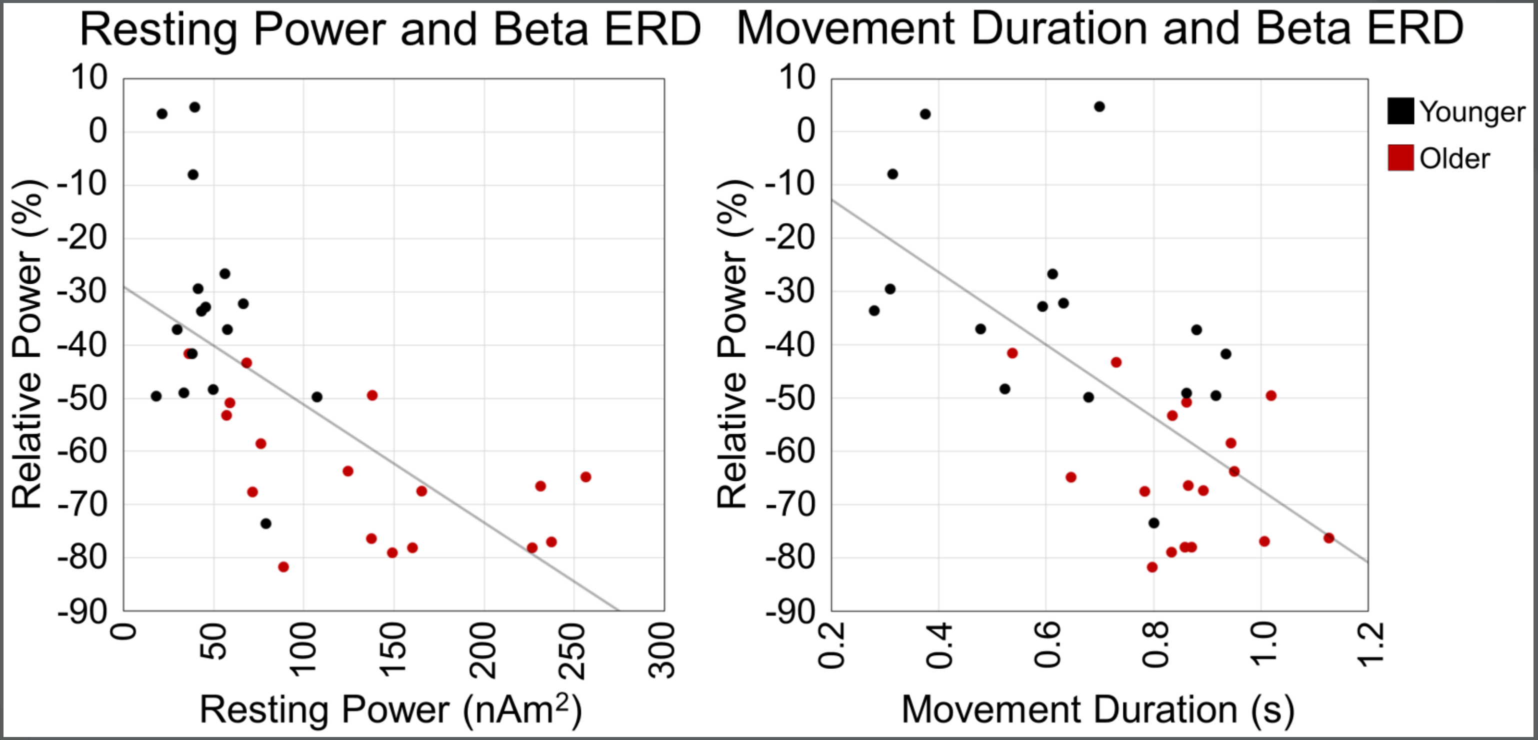


Heinrichs-Graham & Wilson, *Neuroimage*, 2016



Heinrichs-Graham & Wilson, *Neuroimage*, 2016

Correlations with Performance



Heinrichs-Graham & Wilson, *Neuroimage*, 2016

More about the relationship between spontaneous beta and motor-related beta activity

Heinrichs-Graham et al., *Developmental Cognitive Neuroscience*, 2018

Trevarrow et al., Poster T-063

DICoN Laboratory

New to the team:
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